From Arkley he went to live at Bush Hill Park, Enfield, and in 1888 he again removed, to Strawberry Hill, Twickenham, to be near his daughter and her husband. There in 1892 June his wife died. Mr. Campbell felt his loss acutely, and never entirely recovered either health or spirits, though up to this time he had been a man of robust constitution, singularly simple in tastes and habits. In 1894 December he caught a severe cold, which ended in influenza and severe bronchitis, and after a painful illness of a few days he passed away on December 11 in his seventy-third year.

During his latter years Mr. Campbell bore many severe trials with wonderful patience and fortitude, and these, instead of souring or embittering, seemed to show up more strongly the sterling qualities of his mind and nature. To the last he retained his devotion to learning and science and his wonderful love for animals, especially dogs. For over forty years he possessed a very fine breed of Newfoundlands. Several generations had been his loved companions; he was never without one or two wherever he went. "Mr. Campbell's great dogs" were as well known as himself.

[For many of these particulars the Council is indebted to Mr. Campbell's daughter, Mrs. Campbell-Heap.]

ARTHUR CAYLEY was the second son of Henry Cayley, a Russia merchant settled at St. Petersburg. He was born at Richmond, Surrey, on 1821 August 16, during a short visit of his parents to this country. The family returned permanently to England in 1829, and after a time fixed their residence at Blackheath, Kent. He was sent to a private school at that place, kept by the Rev. G. B. F. Potticary, and at the age of fourteen he went to King's College School, London. He came up to Trinity College, Cambridge, in 1838, and graduated in 1842 as Senior Wrangler and First Smith's Prizeman. It has often been the subject of remark that four such distinguished mathematicians as Leslie Ellis, Stokes, Cayley, and Adams should have been senior wranglers in four successive years.

Cayley was elected Fellow of his college in the year in which he took his degree, and was assistant tutor for about three years. As he did not take holy orders his fellowship was only tenable for a limited term, and it was necessary for him to select a profession. He chose the Bar, and about 1847 he became a pupil of the eminent conveyancer, Mr. Christie. He was called to the Bar in 1849, and during the time that he practised was always supplied by Mr. Christie with as much conveyancing work as he was willing to undertake.

As an undergraduate he had shown very marked mathematical ability, and had already published two or three papers in the *Cambridge Mathematical Journal* at the time of the examination for his degree. The *viva voce* part of the examination still existed then, and Mr. Gaskin, the Senior Moderator, told him that he was acquainted with his papers and need ask

him no questions. During the time in which he resided at Cambridge after his degree, and while at the Bar, he was incessantly occupied with mathematical investigations, and it was during this period of his life that some of his finest work was produced.

Certain lectureships on algebra, tenable for ten years, in each of the colleges at Cambridge were founded by Lady Sadler at the beginning of the last century, and had existed from 1710 till 1860. In the latter year a statute was sanctioned which enacted that after that date no more lecturers were to be appointed, and that when so many vacancies had occurred that not more than one-half of the net income of the foundation was required for the payment of the remaining lecturers a Sadlerian professorship of pure mathematics was to be established. The requisite number of vacancies occurred in 1863, and Cayley was elected the first Sadlerian professor. He willingly gave up the prospect of great legal eminence in order to devote his whole time and thought to his favourite subject, and at once returned to Cambridge. Perhaps no professorship was ever founded more opportunely.

There is scarcely any department in the whole range of mathematical literature which was outside the field of Cayley's work, and even among the minor subdivisions of mathematics it is difficult to think of a subject which did not claim his attention at some time in his life. He was a most prolific writer, and probably equalled Euler in versatility and facility of production. The regions most extended by his labours were, perhaps, Algebra, Analytical Geometry, and the Integral Calculus, but he also contributed largely to the Theory of Numbers. About 1856, when he had already published more than 150 papers on subjects relating to pure mathematics, he seems to have been attracted to dynamics and elliptic motion, for in that year he contributed a paper on the "Theory of Elliptic Motion" to the *Philosophical Magazine*, and his report on the "Recent Progress of Theoretical Dynamics" appeared in the *Report of the British Association* for 1857. He also wrote a paper on "Hansen's Lunar Theory," in the *Quarterly Journal of Mathematics* for 1857, and (in the same volume) a note on "Jacobi's Formulæ for Disturbed Motion in an Elliptic Orbit." He was elected a Fellow of our Society on 1857 July 10, and during the next few years communicated several elaborate memoirs relating to the development of the Disturbing Function, which were printed in vols. xxvii.–xxxi. of the *Memoirs*. When Adams's value of the secular acceleration of the Moon's mean motion was so strenuously controverted by Pontécoulant and others, Cayley undertook an independent calculation of the coefficient of the term in dispute, his result confirming Adams's value. This paper was printed *in extenso* in the *Monthly Notices* for 1862. Cayley's subsequent communications to the Society were numerous; but, with the exception of the papers relating to Delaunay's lunar theory, they may be said to have related chiefly to mathematical questions

that fell within the domain of astronomy rather than to astronomy itself. For example, the elaborate memoirs on the determination of the orbit of a planet from three observations, and on the geodesic lines on an ellipsoid, contain little that concerns even a mathematical astronomer, unless he were also interested in pure mathematics. It may here be mentioned that projections and graphical methods always had a special attractiveness for Cayley; his inclination towards these subjects is shown in several of his papers published by the Society.

In 1859 December he became the editor of the publications of the Society, in succession to Mr. Grant, who had been appointed Professor of Astronomy at Glasgow. The *Monthly Notices* and *Memoirs* were edited by him continuously from that time until 1882, except during the two years of his Presidency, 1872–74, when the editorship was undertaken by Mr. Proctor. Cayley was a Member of Council from 1858 until 1893, and during nearly the whole of that period he was a regular attendant at the meetings.

The duties of the Sadlerian professor were "to explain and teach the principles of pure mathematics and to apply himself to the advancement of that science." Cayley delivered one course of lectures in the Michaelmas term of each year until the professorship was placed under the new statutes in 1886, after which he lectured in the Lent term also. The teaching work attached to the professorship was therefore very small, and he was free to devote his whole energies to the advance of his subject. How splendidly he availed himself of his opportunities is shown by his writings, which have influenced every branch of mathematics. In mere extent they are very considerable, exceeding 800 in number.

It is difficult to do adequate justice to Cayley's merits as a mathematician, so great and varied were his powers and so wide the range of subjects to which they were applied. It is, perhaps, as one of the principal founders of the modern higher algebra that his name is best known. It is forty years since these notable researches of Cayley and Sylvester followed each other in such quick succession. Salmon also bore a part, and it was by his well-known treatise that the newly-discovered subject was rendered available to students. With the exception of quaternions, this is the only branch of mathematics which this country can claim the honour of having originated and developed. Cayley's great memoir on elliptic functions, in which they were derived from the doubly periodic products, appeared as long ago as 1845. He also made other important contributions to this subject, being especially interested in the algebraical theory of transformation and the modular equations. The theories of curves and surfaces were greatly extended by his labours. Reference should also be made to the geometry of n dimensions, which frequently occupied his attention at all times in his life. The only separate book published by him was a treatise on *Elliptic Functions* which appeared in 1876.

The republication of Cayley's collected papers was undertaken by the Cambridge University Press in 1889, and seven volumes, containing 485 papers, had been issued under his own editorship at the time of his death. Since then two additional volumes, carrying the papers down to 1877, have been issued under the editorship of Professor Forsyth. The number of papers contained in the nine volumes is 629, and it is announced that the completed works will probably extend to thirteen volumes. Some idea of the mass of work published by Cayley may be obtained when it is stated that each volume is a quarto of 600 or more closely printed pages.

With respect to the character of Cayley's work, it is scarcely possible to exaggerate his immense grasp over the analytical processes. As an algebraist it is probable that he has never been surpassed. He seemed able to apply algebraical methods to every kind of subject with masterly success, and to possess the gift of discovering the right "handle" wherewith to take hold of a subject, so to speak. An extraordinary command over the management of symbols, and a penetrating insight into the truths that underlay the formulæ, were perhaps the most conspicuous of the qualities which enabled him to do lasting work in every branch of mathematics. In preparing his work for publication Cayley seemed to care only for the substance, attaching but little importance to elegance of form or simplicity of development. He made no attempt to exhibit his results in their most attractive form; in fact, when he had been occupied on a subject for some time, he would frequently put together the work he had done pretty much as it stood, and send it for publication. He always printed his investigations as he did them, and at no time were there any considerable accumulations. We owe it to this habit that he has left no arrears of unfinished work.

His power of entering into the researches of others was hardly less remarkable than his wonderful capacity for original work. By merely "dipping into" a difficult foreign memoir he was able to seize the meanings of the symbols and comprehend the principal results without reading the investigation itself. The theorems which he had thus mastered he would frequently prove by a method of his own (generally algebraical), almost always carrying the investigation further. This gift of almost instantaneously grasping and seeing in a new light the results of others contributed in no slight degree to increase the great reputation his writings had won him on the Continent. As regards the nature of his own work, he was essentially a great explorer; he loved to explore anywhere, and he was always tempted by any newly discovered territory. This universality of his tastes, and his great fertility, are very remarkable characteristics. He had no liking for the philosophy of mathematics, and did not care much to contemplate existing knowledge, or dwell upon what he had accomplished himself. Each new result would seem to have presented itself to him principally as a fresh point of departure for

new investigations. He was fond of making *résumés* of work done on a special subject, but his object generally was to clear the ground for future research.

Cayley's lectures almost invariably related to a subject upon which he was then engaged, and the lectures themselves sometimes contained the results of work done since the preceding lecture. For example, the paper already referred to, on the determination of the orbit of a planet from three observations, formed the subject of one of his courses of lectures before it was completed and presented to our Society. He did not give the same course of lectures twice, nor did he ever prepare a course of lectures distinct from work that was occupying his attention at the time. The general expression of his views on any branch of mathematics and his mode of work were interesting; but he had not the art of teaching, nor was the matter or arrangement of his lectures suitable for those who were previously unacquainted with the subject. The attendance was small, and the lectures did not form part of the ordinary course of mathematical study in the university. He was a good correspondent, and to letters asking for information on mathematical questions he always returned full and prompt replies. A vast number of mathematical papers submitted to scientific societies were referred to him; and in all such cases he was an admirable referee. He had a clear and definite idea of the standard of excellence—not an unduly high one—that should be maintained, and his reports were always valuable and practical.

After 1863 he spent the remainder of his life in Cambridge, principally occupied by mathematical research. He undertook, however, a very considerable amount of voluntary work for bodies with which he was connected. He freely placed his time, legal knowledge, and skill at the disposal of his university and college, and of the scientific societies to which he belonged. The present statutes of Trinity College, Cambridge, were principally drafted by him, and during the years in which he was one of the members of the Council of the Senate he undertook a good deal of work of the same class for the university. One of the last services of this kind which he performed was the drafting of the regulations of the Isaac Newton studentships, founded by Mr. McClean in 1890. On councils, or committees, or syndicates in the university he was always one of the most valued members. He spoke only when he had something of importance to say, and was always listened to with respect. He was perfectly fair-minded, and possessed a sound judgment and a temper that could not be ruffled. Though conservative in most matters, he was free from general political bias. At the elections to the Council of the Senate at Cambridge he was usually nominated by both parties, and in other cases, where there was a conflict of opinion he was invariably supported by all sides. He was retiring in disposition and very shy in manner, though less so in the latter part of his life. He was singularly unfitted for party strife in any form, and was

always unwilling to concern himself with the conduct or motives of others. His character, however, was a strong one, and he never allowed himself to swerve from what he believed to be his duty. He was businesslike in the affairs of ordinary life, and everything that fell to him to do was well and punctually done. He took a special interest in matters relating to finance, and only a few months before his death published a pamphlet on book-keeping. He steadily supported the movement for the promotion of the higher education of women from the first, and for some years was Chairman of the Council of Newnham College.

He was a good linguist, and was an eager reader of fiction all through his life. He was also interested in painting and architecture, and derived much comfort from his acquaintance with these subjects in his long and wearisome illness. He was very fond of walking up to the last few years of his life, and took an especial delight in mountain scenery. Although not social in the ordinary sense of the word, he was not a recluse, but liked the society of his friends, who were always welcome to his house.

He was President of the London Mathematical Society, 1868–70, of the Cambridge Philosophical Society, 1869–71, and of the British Association at the Southport meeting in 1883, on which occasion the subject of his presidential address was the progress of pure mathematics. When he was President of our Society in 1874 he delivered the address in presenting the gold medal to Professor Simon Newcomb. He was elected Fellow of the Royal Society in 1852. In 1872 he was elected honorary Fellow of Trinity College, and in 1875 he was re-elected an ordinary Fellow, a position which he retained for the remainder of his life. In 1882 he accepted an invitation from the Johns Hopkins University, Baltimore, to give a course of lectures during the winter session. These lectures were delivered in the first five months of 1882.

The honours he received were almost as numerous as could fall to the lot of any scientific man. Degrees were conferred upon him by the Universities of Oxford, Dublin, Edinburgh, Göttingen, Heidelberg, Leyden, and Bologna; and in 1888 he received, in conjunction with Stokes and Adams, the honorary degree of Sc.D. from his own university. He was an officer of the Legion of Honour; a foreign associate of the French Institute, and of the Academies of Berlin, Rome, and other cities. He received the Copley and Royal Medals from the Royal Society, the De Morgan Medal from the London Mathematical Society, and the Huyghens Medal from Leyden. His portrait was painted in 1874 by Mr. Lowes Dickinson, and presented by the subscribers to Trinity College, where it now hangs in the hall. A reproduction of this portrait appeared in the sixth volume of his collected works, and a sketch, made at the same time by Mr Lowes Dickinson, was prefixed to the seventh volume. There is also a bust of him in the library of Trinity College.

Towards the end of 1892 his health began gradually to fail, and he had occasional attacks of severe illness, which confined him to his bed for weeks together, each leaving him weaker than before. One of these attacks occurred on 1895 January 8, but he seemed to be getting better, when on January 21 he began to grow rapidly weaker, and died about six o'clock on the evening of Saturday, January 26. He was interred at Cambridge on the following Friday, the funeral service taking place in Trinity College, when the large assemblage of senior members of the University, of the representatives of Governments and societies, and friends from a distance, testified to the respect and estimation in which he was held.

In 1863 he married Susan, daughter of Robert Moline, of Greenwich. His wife and two children survive him. His valuable mathematical library has been presented by Mrs. Cayley to Trinity College and Newnham College. J. W. L. G.

Edward John Collingwood was born on 1815 February 4, at Chirton House, North Shields. His residences were Lilburn Tower and Chirton House, but he sold the latter some years ago. He built an observatory at Lilburn Tower about the year 1852, in which he placed a $6\frac{1}{3}$-inch refractor, equatorially mounted, and a 4-inch transit instrument; but his eyesight failed shortly after the instruments were mounted, and he was unable to do much astronomical work.

He married in 1842 Anna, daughter of the late Arthur Burdett, of Co. Tipperary and King's County, by whom he had issue three sons and two daughters, all of whom survive him. He died at Lilburn Tower on 1895 February 20. Mrs. Collingwood died in 1879.

He was elected a Fellow on 1851 February, but contributed no papers to the Society.

[For these particulars the Council is indebted to his son, Mr. Edward J. Collingwood.]

Richard Dunkin was born at Truro on 1823 June 9. He was the fourth and youngest son of Mr. William Dunkin, who was for nearly thirty years one of the established computers of the old edition of the *Nautical Almanac*, and afterwards a member of the staff of the *Nautical Almanac* office, on its reorganisation in 1831 under the direction of Lieutenant Stratford, R.N., F.R.S. R. Dunkin received his general education at private schools at Truro and Camden Town, London, and finally at a well-known French school at Guines, near Calais, where he remained until the death of his father in 1838 July. In the following month, August 21, through the recommendation of Mr. Davies Gilbert, F.R.S., a Past President of the Royal Society, and Lieutenant Stratford, he and his elder brother were engaged by the Astronomer Royal for special employment in a new department of the Royal Observatory, then recently established